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LIFE FORWARD

INTRODUCTION

TRANSPORT OF RADIOPHARMACEUTICALS

RADIATION PROTECTION FROM START TO END

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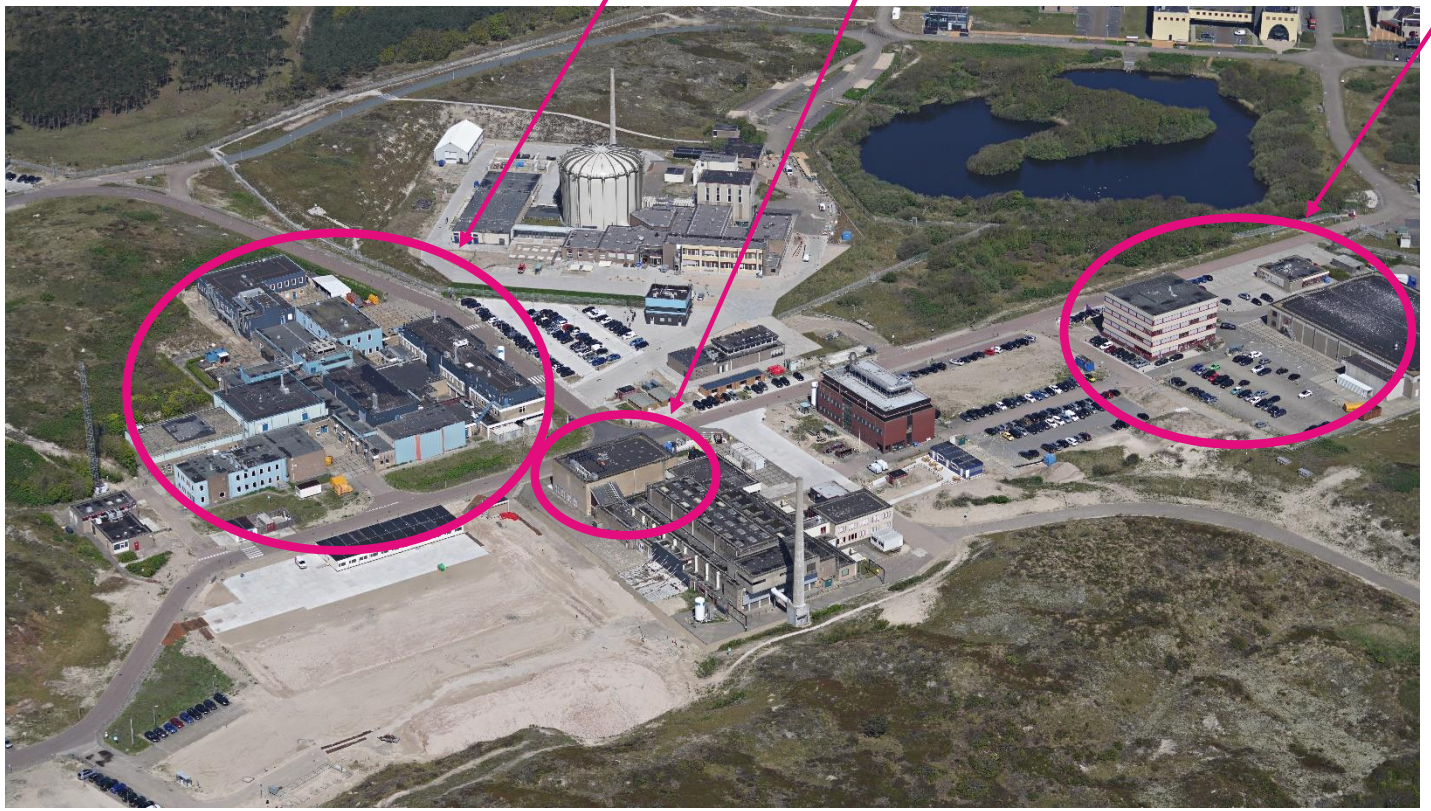
EAN Workshop, April 2025

CONTENT

SUBJECTS

- Curium Netherlands B.V.
- Introduction to transport of radioactive material
- Transport radiopharmaceuticals
- Focus: examples of radiation protection at the packing of radiopharmaceuticals

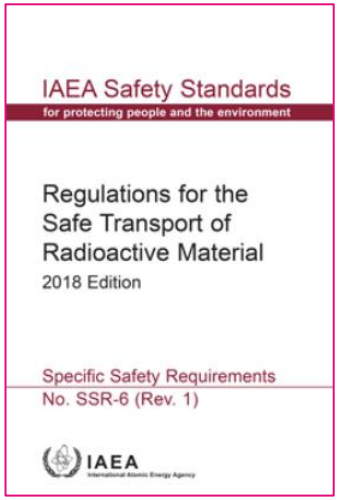
CURIUM NETHERLANDS B.V.



Curium in Petten:

- ± 350 employees
- Delivery to 60+ countries, appr. 190.000 pck class 7/year
- 100% Focus on Nuclear Medicine
- Market Leader in Nuclear Medicine

TRANSPORT OF RADIOACTIVE MATERIAL



Introduction to transport of radioactive material

- Dutch Legislation:
- Nuclear Energy Act
  - Decree on Basic Safety Standards
  - Decree on Transport
    - By Road: VLG, ADR
    - By Air: ICAO (and IATA)
- Basis for the transport: IAEA, Regulations for the Safe Transport of Radioactive Material, SSR6-2018.

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TRANSPORT EXAMPLES

EXTRA REQUIREMENTS

Transport radiopharmaceuticals:

- Customs, EU Directives Airfreight Security
- Legislation Product Quality, Registration
- Good Manufacturing Practices
- Good Distribution Practices, a.o.
  - Temperature control
  - Clean environment
  - Recall, Interception procedure

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SUPPLY CHAIN MO-99

Raw material

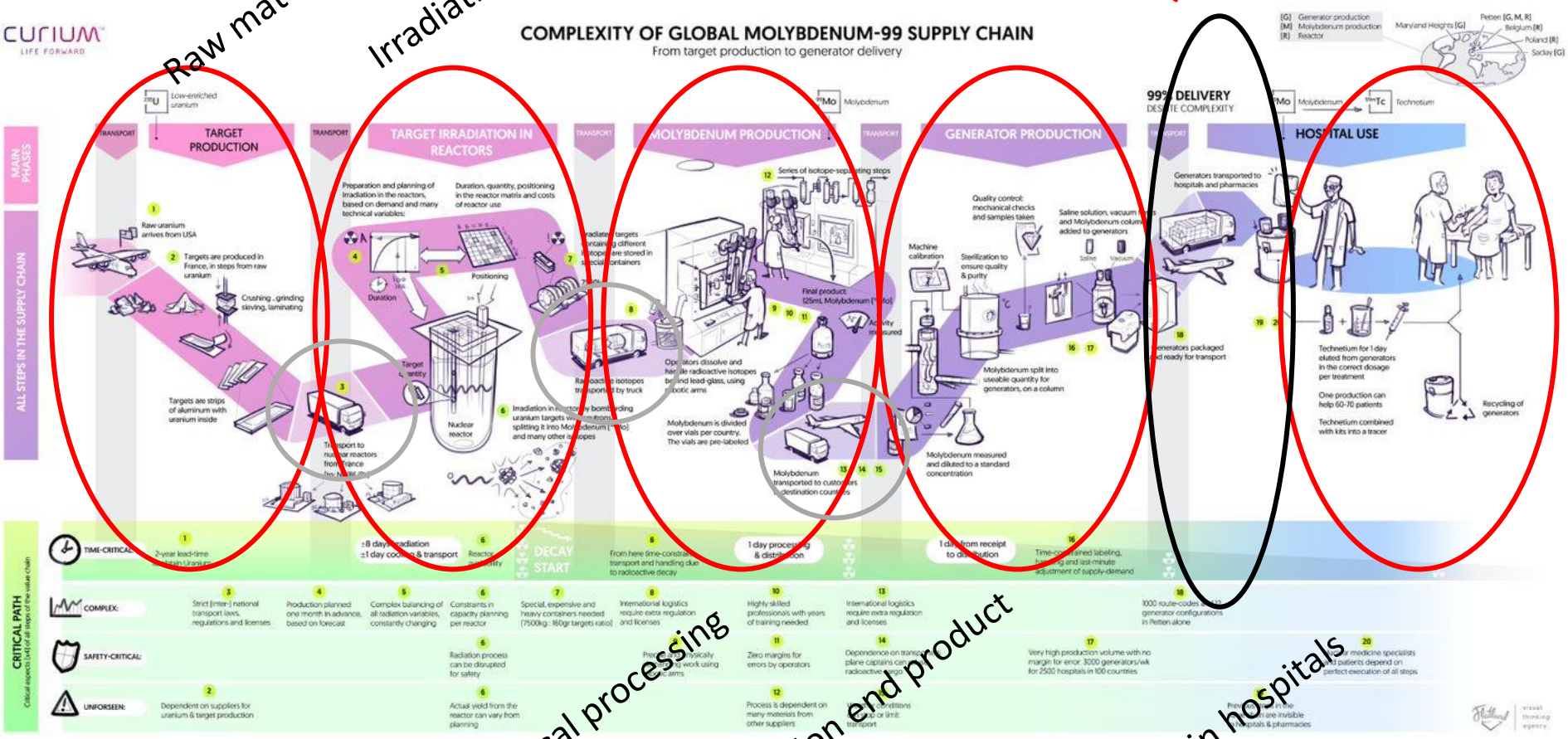
Irradiation

TRANSPORT

Chemical processing

Production end product

Use in hospitals



OBLIGATIONS

TRANSPORT
RADIOACTIVE PHARMACEUTICALS

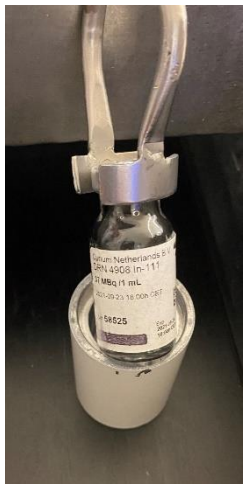
- Consignor responsibilities
- License check customer,
  - Radioactive material
  - Pharmaceutical
- Classification
- Packing
- Shipment documentation (+ stowage)
- Carrier responsibilities
- Consignee responsibilities

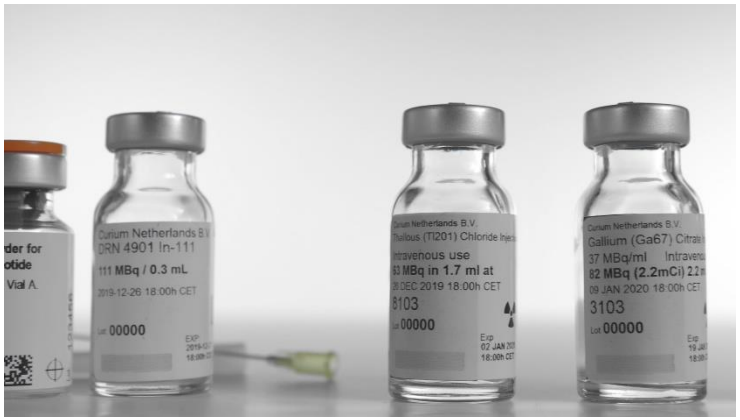
Radiation Protection?
√
√
√
√
√

FOCUS ALARA

2 EXAMPLES ON A.L.A.R.A.

- ^{99m}Tc-Generator
- Cyclotron products





EXAMPLE 1

EXAMPLE ^{99M}TC-GENERATOR

Lifting the packages semi manual (1990's, up to 22 kg/pc):

Collective dose: ± 140 mSv/y

(70.000 pc/y, 14 persons)

EXAMPLE 1

EXAMPLE ^{99M}TC-GENERATOR

Lifting the packages by robot (2000):

Collective dose: ± 90 mSv/y

(70.000 pc/y, 17 persons)

EXAMPLE 2

EXAMPLE ^{99M}TC-GENERATOR

Policy:

Max Surface DoseRate on packages: 2 mSv/h (a.o.)

History:

- 5 Pb thicknesses:
- 28 mm
- 35 mm
- 42 mm
- 49 mm
- 56 mm

Current:

- 1 type Pb thickness:
- 56 mm

EXAMPLE 2

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Ship time Petten	Shielding	Ordered Activity at Activity Reference Time (ART)																					
		2.15 GBq		4.30 GBq		6.45 GBq		8.60 GBq		10.75 GBq		12.90 GBq		17.20 GBq		21.50 GBq		25.80 GBq		30.10 GBq		34.40 GBq		43.00 GBq	
		TI[1)]	SR[2)]	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR
09:30	L35																								
	L42																								
	L49																								
	L56																								
11:00	L35																								
	L42																								
	L49																								
	L56																								
12:00	L35																								
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14:30	L35																								
	L42																								
	L49																								
	L56																								
15:30	L35																								
	L42																								
	L49																								
	L56																								
10:00 Weekend Generators	L35																								
	L42																								
	L49																								
	L56																								

Ordered Activity at Activity Reference Time (ART)

10.75 GBq | 12.90 GBq | 17.20 GBq | 21.50 GBq

SR | TI | SR | TI | SR | TI | SR | TI | SR

Shielding

L35

L42

L49

L56

TI: Transport Index

SR: Surface doseRate

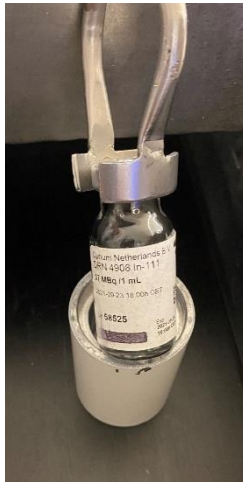
EXAMPLE 2

Ship time Petten	Shielding	Ordered Activity at Activity Reference Time (ART)																					
		2.15 GBq		4.30 GBq		6.45 GBq		8.60 GBq		10.75 GBq		12.90 GBq		17.20 GBq		21.50 GBq		25.80 GBq		30.10 GBq		34.40 GBq		43.00 GBq	
		TI[1]	SR[2]	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR	TI	SR
09:30	L56																								
11:00	L56																								
12:00	L56																								
14:30	L56																								
15:30	L56																								

Achieved dose reduction employees Packing by reducing Pb thicknesses: unknown, accomplished by appr. 10 years, gradually changing processes.

EXAMPLE 3

EXAMPLE
SHIELDING
CYCLOTRON
PRODUCTS



EXAMPLE 3

EXAMPLE

SHIELDING CYCLOTRON PRODUCTS

History:

➢Minimum of 2 mm Pb shield

Current situation:

➢6 mm Pb shield

Current collective dose at Packing appr. 50 mSv/y.

END

CONCLUDING

- ✓ By continuous attention on dose and dose reduction through the years a real reduction in collective dose has been achieved.
- ✓ Individual workers' dose at Packing has been reduced from 10 – 15 mSv/y (1990's) to less than 6 as from appr. 2010.

CLOSE OUT

THANK YOU FOR YOUR ATTENTION